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SHORT COMMUNICATION

Flowshop scheduling with respect to transport time, break-time and weight of jobs using Nawaz, Enscor and Ham (NEH) methods

Muhammad Faudzi Bahari[1,*], Elis Ratna Wulan[2], Arief Fatchul Huda[2], Sudradjat Supian[3], Subiyanto[4]

[1]Master Program in Mathematics, Faculty Mathematics and Natural Science, Universitas Padjadjaran, Indonesia

[2]Department of Mathematics, Faculty Science and Technology, Universitas Islam Negeri Sunan Gunung Djati Bandung, Indonesia

[3]Department of Mathematics, Faculty of Mathematics and Natural Science, Universitas Padjadjaran, Indonesia

[4]Department of Marine Science, Faculty of Fishery and Marine Science, Universitas Padjadjaran, Indonesia

*E-mail address: mfaudzibahari@gmail.com

ABSTRACT

This research discusses a production scheduling by using flowshop type production scheduling with respect to transportation time, break-time and weight of jobs. The data used are four job scheduling on three machines. In addition, there is inter-machine transport time. The method was used in this research is NEH Method. Based on the results, the NEH method obtained a makespan value of 56 hours with a weighted mean flow time of 34.07 hours.

***Keywords*:** Scheduling, Flowshop, NEH, Makespan, Weighted Mean Flow Time

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1. INTRODUCTION

In the production scheduling process there are two types of scheduling, namely flowshop scheduling and jobshop scheduling [2], [4], [5]. The difference is the flow of the production process. Flowshop scheduling has static flow, while on jobshop scheduling is dynamic. Some scheduling models generally assume that every production process is always carried out in the same production site so there is no inter-process transport time. In fact, there are quite a few companies that do the production process not in the same production site, so there is transport time between processes. For special cases like this, some researchers have conducted research on similar topics, including Ahmad [1], Ancau [3], Baskar [6], Berhan [7], Chandramouli [8], Ichiro [17], Hyung-Jun[16], Khodadadi [18], Dominik Jena [10], Gao [11], Deepak Gupta [9], [12], [13], Hadda [14], Hossain [15], Kubo [19], Liu [20], Modrak [21], Pandian [22], Reza [23], Sadjadi [24], Semanco [25], Singhal [26], Taillard [27], [28], Wang [29], and Wu [30]. In this journal we are testing the production scheduling of flowshop type with respect to transport time, break-time and weight of jobs using NEH method. Let some jobs i (i = 1, 2, ..., n) should be processed on machine A, B, C, D in the ABCD sequence. Let Ai ', Bi', Ci', Di 'be the processing time of the work in machines A, B, C, D ... respectively. Suppose tis → s + 1 becomes the transport time from one machine to another. Let Wi be the weight of jobs for the i-th job. Assume that while the production process is in progress the machine gets a break-down problem with a fixed time interval (a, b) due to power cuts. The mathematical model of the problem given in the matrix form can be expressed as Table 1.

Table 1. Problem Formulations.

Job	A	$t_{i1\to2}$	B	$T_{i2\to3}$	C	Wi
1	A1	$t_{11\to2}$	B1	$t_{12\to3}$	C1	W1
2	A2	$t_{21\to2}$	B2	$T_{22\to3}$	C2	W2
...	...	...	...	..	...	..
N	An	5	Bn	1	Cn	Wn

The objective of this research is to find the optimal sequence of problems with considering total production time (makespan) and average Weighted Mean Flow Time.

2. MATERIALS AND METHODS

2. 1. Notations

Ai : Expectations of the i-th job process time on machine A
Bi : Expectations of the i-th job process time on machine B
Ci : Expectations of the i-th job process time on machine C
Di : Expectations of the i-th job process time on machine D

Ri	:	Expectations of the i-th job process time on the fictitious machine R
Si	:	Expectations of the i-th job process time on the fictitious machine S
Ti	:	Expectations of the i-th job process time on the fictitious machine T
Ri’	:	Expectations of the i-th job process time on the fictitious machine R Post-Minimization Weight of job
Si’	:	Expectations of the i-th job process time on the fictitious machine S Post-Minimization Weight of job
Ti’	:	Expectations of the i-th job process time on the fictitious machine T Post-Minimization Weight of job
$t_{is \rightarrow s+1}$	:	The transport time of the i-th job moves to the next machine (s = 1,., m-2)
Ai’	:	Expectation of the i-job process time after the break-down effect on machine A
Bi’	:	Expectation of the i-job process time after the break-down effect on machine B
Ci’	:	Expectation of the i-job process time after the break-down effect on machine C
Di’	:	Expectation of the i-job process time after the break-down effect on machine D
Wi	:	Weight Of Jobs
L	:	Length of Break-time

2. 2. Algorithm

i. Create a fictitious machine that can simplify transport time
Ri = Ai + ti1 → 2
Si = Bi + ti2 → 3
Ti = Ci

ii. Minimize weight with the formula defined as follows:
Ri " = Ri / Wi
Si " = Si / Wi
...
Mn '= Mn / Wn

iii. Create new partitions as many as i + 1 partitions with the smallest weight of jobs.

iv. Compare makespan of each partition.

v. Select the partition with small makespan. If there is the same partition, select the partition with the smallest mean value of flow time. If still the same, select the partition at random.

vi. Check whether each job is included in the selected partition. If all jobs are included in the selected partition, then the sequence is the optimal sequence. If not, repeat steps 2, 3, and 4.

vii. Checking job-jobs affected by breakdown effects

viii. Adds a breakdown effect to job-jobs affected by breakdown effects

ix. Sets new time expectations in the order they get

x. Find the weight of the plot by defining $F = \sum_{i=1}^{n} wifi / \sum_{i=1}^{n} fi$.

2. 3. Numerical example

A production with 4 pieces Job will be operated on 3 pieces of machine. However, at any time to 17 to 22 (in a matter of hours) the machine will experience constraints in its operation. This problem is made the object of research as shown by Table 2.

Table 2. Object of Research.

Job	A	$t_{a\to b}$	B	$t_{b\to c}$	C	Wi
1	10	2	7	2	5	3
2	8	3	6	5	9	5
3	7	1	3	4	5	4
4	5	4	2	1	6	2

3. RESULT AND DISCUSSION

After applying the algorithm used in the research object produce the sequence, makespan and weighted mean flow time as follows Table 3.

Table 3. Sequence Result Using NEH Methods.

Part	Completion	Mean Flow time
2-3	36	-
3-2	38	-
1-2-3	46	-
2-1-3	41	27,3
2-3-1	41	28,3
4-2-1-3	46	-
2-4-1-3	47	-
2-1-4-3	47	-
2-1-3-4	47	-

From Table 3, we see that makespan minimum is given by sequence is 4-1-2-3. So, next step is makes schedule with that sequence as follows Table 4.

Table 4. Optimal Sequence Using NEH Methods.

Job	A	$t_{a\rightarrow b}$	C	$t_{b\rightarrow c}$	E
4	0-5	5-9	9-11	11-12	**12-18**
2	5-13	13-16	**16-22**	**22-27**	27-36
1	**13-23**	23-25	25-32	32-36	36-41
3	23-30	30-31	32-35	35-39	41-46

From Table 4, we see that some of jobs is proceed on the breakdown interval. We know on the breakdown interval no ones jobs can proceed on the machine. Some jobs will continue proceed after the breakdown interval. Now, every job was affected by breakdown have the new expected time proceed as follows Table 5.

Table 5. Expectations time proceed after breakdown.

Job	A	$t_{a\rightarrow b}$	C	$t_{b\rightarrow c}$	E
1	15	2	7	2	5
2	8	3	11	10	9
3	7	1	3	4	5
4	5	4	2	1	11

After that we reset it using the sequence obtained from Table 3. So the scheduling is shown as in Table 6.

Table 6. Optimal Scheduling.

Job	A	$t_{a\rightarrow b}$	C	$t_{b\rightarrow c}$	E
4	0-5	5-9	9-11	11-12	12-23
2	5-13	13-16	16-27	27-37	37-46
1	13-28	28-30	30-37	37-39	46-51
3	28-35	35-36	37-40	40-44	51-56

From Table 6 we see that the sequence obtained produces makespan of 46 hours. Next, we will look for a weighted mean flow time. For that we must know the mean flow time and weight of jobs of each job. Mean flow time and weight of job are shown by table 7. (Gupta, Sharma, & Sharma, Heuristic Approach for n-Jobs, 3-Machines Flow Shop Scheduling Problem, Processing Time Associated With Probabilities Involving Transportation Time, Break-Down Interval, Weightage of Jobs and Job Block Criteria, 2011)

Table 7. Mean Flow Time and Weight of Jobs.

Job	fi	Wi	Wi.fi
1	38	3	114
2	41	5	205
3	28	4	112
4	23	2	46

Now we can calculate the weighted mean flow time defined as $F = \frac{\sum_{i=1}^{n} Wi.Fi}{\sum_{i=1}^{n} fi}$.

$$F = \frac{114 + 205 + 112 + 46}{14} = \frac{477}{14} = 34{,}07\ hours.$$

4. CONCLUSIONS

From Table 2 we see that NEH method is able to solve flowshop scheduling problem with total makespan of 56 hours. Then, from Table 3 we see flow time and weighted flow time of each jobs. So, in the end we get the value of weighted mean flow time of 34.07 hours.

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